

The Effect of the Glacial Epoch upon the Distribution of Insects in North America. By AUG. R. GROTE, A.M.

From the condition of an hypothesis the Glacial period has been elevated into that of a theory by the explanations it has afforded of a certain class of geological phenomena. The present paper endeavours to show that certain zoological facts are consistent with the presence, during past time, of a vast progressive field of ice, which, in its movement from north to south, gradually extended over large portions of the North-American continent. These facts, in the present instance, are furnished by a study of our Lepidoptera, or certain kinds of butterflies and moths now inhabiting the United States and adjacent territories. Before proceeding with the subject, a brief statement of the phenomena assumed to have attended the advent of the Glacial period is necessary.

At the close of the Tertiary, the temperature of the earth's surface underwent a gradual change by a continuous loss of heat. The winters became longer, the summers shorter. The tops of granitic mountains in the east and west of the North-American continent, now in summer time bare of snow and harbouring a scanty flora and fauna, became, summer and winter, covered with congealed deposits. In time the mountain-snows consolidated into glacial ice, which flowed down the ravines into the valleys. Meanwhile the northern regions of the continent, which may have inaugurated the conditions, submitted extendedly to the same phenomena. Glacial ice, first made on elevations, finally formed at, and poured over, lower levels. Glacial streams finally united to form an icy sea, whose frozen waters slowly ploughed the surface of the rocks, and, in their movement from north to south, absorbed the local glacial streams in their course, and extended over all physical barriers. The Appalachians and Rocky Mountains are supposed to have had local glaciers. The animals must always have retreated before this frozen deluge. The existing insects of the Pliocene, in submitting to the change of climate which accompanied the advance of the glacier, must have quitted their haunts with reluctance, and undergone a severe struggle for existence, no matter how gradually they had been prepared for the encounter. We may expect that multitudes of specific forms ultimately perished, of whose remains no traces have been preserved.

After this brief statement of the outlines of the opening of the Glacial period, we turn to some facts offered by a study of certain of our existing species of butterflies and moths.

The tops of the White Mountains and the ranges of mountain-elevations in Colorado offer us particular kinds of insects, living in an isolated manner at the present day, and confined to their respective localities. In order to find insects like them we have to explore the plains of Labrador and the northern portion of the North-American continent, in regions offering analogous conditions of climate to those existing on the summits of these mountains.

The genera *Æneis* and *Brenthis* among the butterflies, and *Anarta* and *Agrotis* among the moths, are represented by the same or similar species in all of the above-mentioned localities. In the case of the White-Mountain butterfly (*Æneis semidea*) we have a form sustaining itself on a very limited alpine area on the top of Mount Washington*. Although there is some doubt whether precisely the same form of *Æneis* has been discovered in Colorado, the fact remains that *Æneis* butterflies exceedingly like it, though registered by us under different specific names, live in Labrador and Colorado. Whether the White-Mountain butterfly (*Æneis semidea*) be, as suspected by Lederer, a modification of some of the Labradorian forms of the genus, or not, the geographical distribution which its genus enjoys cannot be meaningless. The question comes up, with regard to the White-Mountain butterfly, as to the manner in which this species of *Æneis* attained its present restricted geographical area—How did the White-Mountain butterfly get up the White Mountains? And it is this question that I am disposed to answer by the action attendant on the decline of the Glacial period.

I have before briefly outlined the phenomena attendant on the advance of the ice-sheet; and I now dwell for a moment on the action which must equally be presumed to have accompanied its retirement. Many of the features of its advance were repeated, in reverse order, on the subsidence of the main ice-sheet or glacial sea. The local glaciers appeared again, separate from the main body of ice, and filled the valleys and mountain-ravines, thus running at variance with the main body of the glacier, being determined by local topography. A reversal of the temperature shortened the winters and lengthened the summers. Ice-loving insects, such as our White-Mountain butterfly, hung on the outskirts of the main ice-sheet, where they found their fitting conditions of temperature and food. The main ice-sheet had pushed them insensibly before it, and during the continuance of the Glacial period the geographical distribution of the genus *Æneis* had been changed from a high northern region to one which may well have included portions of the Southern States. And, on its decline, the ice-sheet drew them back again after itself by easy stages; yet not all of them. Some of these butterflies strayed by the way, detained by the physical nature of the country and destined to plant colonies apart from their companions. When the main ice-sheet left the foot of the White Mountains, on its long march back to the pole, where it now seems to rest, some of these wayward flitting *Æneis* butterflies were left behind. These had strayed up behind the local glaciers on Mount Washington, and so became separate from the main body of their

* See Mr. Scudder's article in the 'Geology of New Hampshire,' i. p. 342. Mr. Scudder first pointed out the existence of alpine and subalpine faunal belts on Mount Washington, and makes the interesting remark "that if the summit of Mount Washington were somewhat less than 2000 feet higher, it would reach the limit of perpetual snow."

companions, which latter journeyed northward, following the course of the retirement of the main ice-sheet. They had found in elevation their congenial climate; and they have followed this gradually to the top of the mountain, which they have now attained and from which they cannot now retreat. Far off in Labrador the descendants of their ancestral companions fly over wide stretches of country, while they appear to be in prison on the top of a mountain. I conceive that in this way the mountains may generally have secured their alpine animals. The Glacial period cannot strictly be said to have expired; it exists even now for high levels above the sea, while the Esquimaux finds it yet enduring in the far north. Had other conditions been favourable, we might now find Arctic man living on snow-capped mountains within the temperate zone.

At a height of from 5600 to 6200 feet above the level of the sea, and a mean temperature of about 48 degrees during a short summer, the White-Mountain butterflies (*Eneis semidea*) yet enjoy a climate like that of Labrador within the limits of New Hampshire. And in the case of moths an analogous state of things exists. The species *Anarta melanopa* is found on Mount Washington, the Rocky Mountains, and Labrador. *Agrotis islandica* is found in Iceland, Labrador, the White Mountains, and perhaps in Colorado. As on islands in the air these insects have been left by the retiring ice-flood during the opening of the Quaternary.

On inferior elevations (as on Mount Katahdin, in Maine), where we now find no *Eneis* butterflies, these may formerly have existed, succumbing to a climate gradually increasing in warmth from which they had no escape: while the original colonization, in the several instances, must have always greatly depended upon local topography.

I have briefly endeavoured to show that the present distribution of certain insects may have been brought about by the phenomena attendant on the Glacial period. The discussion of matters connected with this theoretical period of the earth's history thus brings out more and more clearly, as it now appears, the fact of its actuality. I hope that my present statements may draw the attention of our zoologists more to the matter, seeing that we have in our own country fields for its full exploration.—*Silliman's American Journal*, Nov. 1875.

On the Reproduction of the Eels. By M. C. DARESTE.

Last year M. Syrski considerably advanced the question of the reproduction of the eels, by showing that in certain eels there exist in the place of the female reproductive organs, some organs of quite different form and structure. M. Syrski regards these as male reproductive organs. The description which he gives of their form and structure renders his opinion very probable. It must, however, be added that M. Syrski could not ascertain the existence of spermatozooids in these organs, the proof of which alone could serve to demonstrate certainly their true nature.